The impacts of ridesourcing services

Subjects: Social Issues

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By applying an algorithm based on pickup and drop-off locations, transportation network companies (TNCs) match passengers who need a ride with self-employed drivers who tend to provide a trip in their privately owned cars. TNCs have expanded their footprint into more cities and are now among the most prosperous and valuable global start-ups. The proliferation of ridesourcing services has raised both hopes and concerns about their role in cities. The impacts of ridesourcing services are complex and multi-faceted.

ridesourcing services TNCs on-demand services sustainability socio-economic impacts environmental impacts

1. Social

1.1. Positive Social Impacts

Ridesourcing services have addressed many of the taxi industry's previous limitations, brought many positive changes, and considerably promoted the service quality [1][2]. It has been argued that TNCs have provided fast, flexible, and convenient mobility options for individuals seeking fast point-to-point services with short pick-up times while avoiding the difficulties of driving [3][4]. Tarabay and Abou-Zeid [5] show that the short pick-up waiting time and the speed of ridesourcing services are the main reason for between 66% and 72% of people to switch from traditional modes to ridesourcing services in Beirut, Lebanon. However, the research population is limited to university students, and it does not completely reflect the sociodemographic profile of Beirut society.

From spatial, temporal, and social perspectives, these services are also considered an opportunity to improve public transportation availability. From a spatial standpoint, these services can provide satisfactory mobility to poor and remote areas where public transport coverage is inadequate [6][7]. The study of Rayle, Dai, Chan, Cervero, and Shaheen [3] in San Francisco finds that ridesourcing can overcome some of the limitations that exist in mass transit, including trips to or from low-density areas. From the temporal perspective, ridesourcing services can potentially bridge the gaps between peak and non-peak hours, daytime and nighttime, weekends and weekdays, and rainy and sunny days in urban transit networks [8]. Adopting a dynamic pricing mechanism and motivating drivers to work harder during peak hours, TNCs have enhanced mobility and responded to taxi demand fluctuation, especially in the morning and evening peaks [9][10]. Ridesourcing is more readily accessible during late nights when transit is less available and waiting for it might feel unsafe [11][12][13]. Moreover, since mass transit cannot afford to provide service on weekends, ridesourcing can offer a viable option for many travelers, including low-income people and non-car owners [14]. This case is true for rainy hours when the need for door to door mobility services is increased [15]. Brodeur and Nield [16] show that rainy hours are associated with an 18%increase in the number of trips carried out by Lyft and Uber in New York City, indicating the demand for ridesourcing services is significantly correlated with increased rainfall. Ridesourcing services provide social equity benefits by providing increased access to transportation for older adults, particularly those that cannot drive [17]. They can also encourage a car-free lifestyle, reduce car ownership, and offer older adults more freedom of movement so they can rely less on friends or family to meet their needs for transportation [18][19][20].

When it comes to safety and security, TNC users and drivers enjoy a better feeling of safety compared to traditional taxi riders and drivers [12][21]. Indeed, the tracking and rating system embedded in ridesourcing services has increased the safety of both drivers and passengers. Based on Glöss et al. [21], surveys conducted in London and San Francisco showed that riders perceived an increased feeling of safety and reliability due to knowing some information about a driver before starting the trip and monitoring the real-time location of the car during the trip. They add that the registration of riders, ratings, and the online tracking of vehicles provided female drivers with a sense of control and security. Moreover, the digital payment system of ridesourcing services can also prevent drivers from being robbed or harmed [13].

The role of ridesourcing services in fighting against drunk driving is also worth pondering. In some cases, what prompts an individual to drive under the influence of alcohol is the insufficient number of taxis, especially at night, and their relatively high price [22]. Therefore, the convenience and flexibility of ridesourcing services may encourage many people to avoid drunk driving [23]. Several studies support this argument. For instance, supported by Uber, Mothers Against Drunk Driving (MADD) reports that the number of drunk drivers 30 years of age or younger has dropped in all U.S. cities where Uber operates [24]. This argument is also supported by independent studies of Rayle et al. [3] in San Francisco and Clewlow and Mishra [25] in major U.S. metropolitan areas, which show that avoiding drunk driving accounts for 21%, and 33% of people are choosing to substitute driving with ridesourcing services.

Evidence shows that, in some places, the entry of ridesourcing services has also been linked with a reduction in traffic collisions, injuries, and fatalities [22]. Based on U.S. county-level statistics from 2007 to 2015, Dills and Mulholland [26] have found a connection between Uber's introduction in the U.S. and a reduction in fatal car collisions and violence. Kontou and McDonald [27] report that a 10% rise in the number of trips can contribute to a 12% reduction in traffic accidents and a 0.25% decrease in impaired driving. However, they do not find a significant relationship between the growth of ridesourcing services and road fatalities.

1.2. Negative Social Impacts

Previous studies have revealed that the access to, use of, and impact of ridesourcing services have been geographically and socially uneven. This has cast doubt on claims that ridesourcing services can provide an affordable mode of transportation and expand the access to public transit for less affluent people and those living in disadvantaged areas [1][6][12][28]. Geographically, ridesourcing services are used more in urban areas, mid-sized and large cities, and neighborhoods with high-density and mixed land uses [29][30][31].

Based on evidence from several U.S. cities, Tehran, and Cairo, there is a consensus among researchers that users of ridesourcing services tend to be disproportionately younger, college educated, and more affluent [32][30][33][34][35]. It is argued that not only are ridesourcing services more expensive than public transit, but their use relies on smartphones and credit cards, imposing financial barriers for low-income people [36][37][38]. In the U.S., Deka and Fei [39] found that the frequency of using ridesourcing services for people who have an income of over USD 150,000 is 62% more than people who have an income of less than USD 25,000, indicating a gap that exists between low-income and affluent people in using ridesourcing services. It can be postulated that the shift of affluent people from transit to ridesourcing can reduce public support for transit subsidies in the future. As low-income individuals are more reliant on transportation and cannot afford to use ridesourcing, their access to transport will be challenged [39]. This limitation is apparent during transit disruptions when low-income ethnic minorities are less likely to choose ridesourcing as an alternative for public transport for mandatory trips [40].

Several studies have argued that these services have so far failed to include physically disadvantaged people [41][42][43]. Under many laws, this group is generally eligible to use travel facilities and no travelers can be rejected on the grounds of disabilities [42]. TNCs have avoided responsibility to warrant non-discrimination and access for the disabled, arguing they are not transportation providers [44]. Besides, Mitra et al. [18] provide evidence from the U.S. suggesting that, due to physical difficulties and a lack of comfort and familiarity with technology, older adults may remain disconnected from the new transport technology.

While discrimination in traditional taxis and ridesharing services is a central preoccupation for public agencies, the ridesourcing industry has also not been immune [28][45]. The studies of E. Brown [45] in Los Angeles and Ge et al. [46] in Seattle and Boston confirm discrimination against African-American riders. It seems that the design of TNCs′ platform allows drivers and riders to learn mutual characteristics, opening up possibilities for discrimination from drivers to riders and vice versa [45][46].

There is also evidence suggesting that the geographic distribution of ridesourcing services is uneven as there have been differences in the availability of these services in urban and rural areas. According to a Pew Research Center survey, there is an adoption gap between urban and rural residents in the USA. Accordingly, 45% of Americans living in urban areas and 40% of suburban residents use a ridesourcing application, while this number is 19% for their rural counterparts [47]. Several studies suggest that ridesourcing is less readily available in small towns and areas with low population and road and pavement network density [18][39][48][49].

TNCs are also blamed for unfair competition with traditional taxis due to avoiding compliance with social legislation, tax regulation, basic wages, and other legal employment rights [50][51][52]. The growth of TNCs has exerted a very disruptive impact on traditional taxi services, contributing to a decrease in taxi ridership and driver income [53][54][55] and leading to social tensions between cab drivers and TNCs in many cities [50]. Nie [54] and Jiang and Zhang [41] show that the growth of ridesourcing services has been associated with a significant loss in the taxi ridership in Shenzhen and Beijing. In the same vein, Brodeur and Nield [56] have found that the number of taxi rides fell by 8% in three years from Uber′s introduction in New York. Based on recent evidence in the UK, 52% of cab firms consider Uber a severe or moderate threat and 79% believe that they should join together to effectively compete with Uber.

A group of scholars poses some questions regarding ridesourcing services′ positive role in safety and security. For example, Brazil and Kirk [57] show that the availability of ridesourcing services has no association with the number of traffic fatalities in the U.S. and concluded that one could not claim that TNCs have made American cities safer. They suggest several explanations for this. First, the number of ridesourcing users is relatively small compared to the total population of licensed drivers and drunk drivers. Second, ridesourcing services may substitute taxicabs and other public transit modes, but not as an alternative mode of travel for drunk driving. Therefore, ridesourcing riders may have been former users of taxis and public transportation and, as a result, the number of at-risk drivers on the road would not noticeably change. Third, as mentioned earlier, some social groups, including low-income, less educated, and older people, have remained largely disconnected from ridesourcing services. Therefore, they may be less likely to consider these services as a substitute for drunk driving. Finally, a portion of the population is not yet convinced that ridesourcing services can provide a safer ride when they are impaired by alcohol. Besides, many drunk drivers consider these services too costly, especially when considering the low likelihood of getting arrested for drinking and driving.

Moreover, whereas public transport agencies usually ensure that traditional taxi drivers have a commercial license and require them to obtain special permissions or training, TNCs have lower entry barriers and only check that drivers have a valid license [58][59]. Edelman and Geradin [43] point out that Uber does not comply with the law and its lower entry barriers may give rise to possible safety concerns. Training can prevent taxicabs from some risks that they would otherwise be unaware of, or by notifying them of preventive measures they might not otherwise follow. Additional risks may also impose drivers and passengers due to insurance. As Edelman and Geradin [43] and Malos, Lester, and Virick [60] suggest, in the U.S., Uber encourages drivers to hold personal insurance rather than a commercial one, overlooking the fact that ridesourcing drivers are more likely to have accidents due to driving more frequently, longer distances, with passengers, and often in unfamiliar and congested places while using smartphone applications. Berneking and his colleagues [61] make a similar argument, pointing out that TNCs employ drivers as “independent contractors,” do not monitor their work hours and rest opportunities, or check them for medical issues that can reduce alertness. These cases have increased the number of fatigue-related accidents. They also added that working as a TNC driver is not a primary job for many individuals and they usually drive after hours of constant wakefulness or during darkness, both of which can raise the risk of drowsy-driving crashes.

2. Economic

2.1. Positive Economic Impacts

Past work suggests that ridesourcing services have positively impacted the taxi industry by tapping into a fresh reservoir of the workforce and shaking the foundation of obsolete structures, regulations, and policies that could have been the key cause of inefficiency [62][54]. Traditional taxis were regulated to charge static fares, leading to equal fares during peak and non-peak hours. Therefore, traditional taxi drivers preferred to drive during non-peak hours, contributing to a taxi supply shortage during peak hours. TNCs address this issue by introducing market-rate pricing, popularly known as “surge pricing.” They encourage drivers to work harder during peak hours to gain more money, increasing taxi supply through surge pricing during peak times [9]. Moreover, by comparing the fares of ridesourcing services with traditional taxis, some scholars argue that TNCs have provided cheaper trips, made it possible for individuals to save costs (fuel and parking), and increased mode choices [36].

TNCs have also provided job opportunities for individuals suffering from job loss or other career setbacks [55][63][64] by establishing an ecosystem for the immediate entry and involvement in the labor market as a freelancer or individual employer (45). Sui et al. [52] point out that Didi Chuxing has attracted a variety of regular car owners in addition to licensed taxis in China, and allows them to provide private trips in their own time. In a study funded by Uber, the Economic Development Research Group estimated that nearly a quarter (23%) of Uber drivers were unemployed before working as a ridesourcing driver [65]. Therefore, TNC riders are viewed as micro-entrepreneurs and a new generation of self-employed drivers who enjoy flexible working hours, appropriate work-life balance, and a family-friendly lifestyle [63][66].

There is also evidence regarding the positive role of ridesourcing services in the car industry. Evidence from China suggests that the initial entry of Didi Chuxing positively impacted new car sales [67]. However, it is not clear if this is a permanent effect. Similarly, Remy et al. [68] discuss that TNCs facilitate drivers′ access to car lenders and dealers and encourage purchasing new cars to join these platforms rather than reusing existing cars.

2.2. Negative Economic Impacts

Although ridesourcing services have created job opportunities for many people, there are concerns about unsecured labor rights, underemployment, and income instability. Labor rights are not secure in the ridesourcing industry and it may shift individuals away from secure employment to unsecured or footloose employment [19]. Moreover, the development of ridesourcing services has pushed many overqualified and educated people into underemployment. This can be due to few entry barriers, coupled with the attractiveness of operating with a technologically advanced platform [60]. Wages also fluctuate in this industry, threatening the income stability of drivers. While drivers cannot easily raise their salaries, TNCs can change their pricing system without seeking the views of drivers [12].

There is also some evidence suggesting that ridesourcing platforms have catered to wealthier people. Due to obstacles, including relatively high costs and the need for a credit card and smartphone, low-income individuals are less able to use ridesourcing [19][69]. Deka and Fei [39] show that the frequency of using ridesourcing services increases with increases in income above USD 50,000 in the U.S. They claimed that while ridesourcing services are cheaper than taxis, these trips tend to be substantially more costly than public transit fares. Notar et al. [70] made a similar argument regarding Uber and Grab drivers in Rangoon, Myanmar. They point out that whereas ridesourcing services have enabled highly skilled and educated people to find a job, people or drivers with fewer resources, such as less education, less literacy, and perhaps no cell phone, will not absorb in this market.

The disruptive impact of ridesourcing services on traditional taxis is reported in several studies [41][56][71]. Evidence in Beijing shows that ridesourcing services contributed to an 18.08% decline in the average passenger delivery trip number per day per taxi and a 19.29% drop in the average daily profit per taxi [41]. A similar point is made by Brodeur and Nield [56], who have found that, after entering Uber into New York City, a decline of around 8% in the number of taxi rides per hour was experienced.

Despite some evidence regarding the positive role of ridesourcing services on the car industry in China by Guo et al. (2018), other studies have yielded conflicting results. Ward et al. [72] showed that following the entry of ridesourcing services, the U.S. metropolitan areas experienced a 3% decrease in per-capita vehicle registrations without any impact on VMT.

3. Environmental

3.1. Positive Environmental Impacts

Given the considerable number of trips made by ridesourcing services, their role in energy consumption, greenhouse gas emissions, congestion, etc., is not negligible. Previous research shows that these taxis have both positive and negative effects on the environment. When it comes to the positive environmental effects of ridesourcing services, ridesourcing is assumed to be green or environmentally friendly since it can increase the use of pre-existing vehicles and reduce empty drives and idle distances [12].

Comparing the capacity utilization of TNC drivers with traditional taxis, ridesourcing services have a higher capacity utilization and productivity rate [41][73]. In comparing taxi and ridesourcing service quality in Los Angeles, Brown and Lavalle [74] notice that TNC users pay 40% lower fares and wait only one-fifth of the time relative to taxis. Nie [54] also shows that TNCs can increase the taxi capability usage rate in the off-peak times in Shenzhen, China. Similar results were obtained in the major U.S. metropolitan cities by Cramer and Krueger [75], who analyze the capacity utilization of UberX drivers based on time and miles. They found that UberX drivers have a 30% higher time utilization rate and a 50% higher miles utilization rate. They list four factors that may explain this difference. Firstly, TNC drivers make use of a technology that suits driver-passenger more effectively. Second, TNCs have a larger scale than taxi companies, which support faster matches. Third, regulations on traditional taxis are inefficient. Finally, the flexible labor supply model of TNCs and their dynamic pricing more closely match supply with demand throughout the day.

It has been argued that the integration of ridesourcing services and public transport can increase the efficiency of the transportation system by serving a niche demand that public transport does not generally serve well [3][48]. The positive impact of ridesourcing services on public transit is that they can extend or complement public transit [76]. When ridesourcing serves the routes and operates at the times that public transport does not serve well, it complements public transit. Ridesourcing can extend public transit by solving the first and last mile problem created by the fixed route and fixed schedule of public transit [3][23][77]. The results of the study of Zgheib et al. [77] show that the integration of ridesourcing and public transport can increase the overall market share of the Beirut

BRT by 2%. They further explored that a 50% reduction in TNCs′ fares can lead to a 3.5% increase in the BRT market share in this city. However, it should be noticed that their model was simple and did not consider correlations across error components.

Moreover, individuals in lower-density urban areas typically suffer from a first and last mile problem due to the comparatively lower transit routes. The potential role that ridesourcing services can play in complementing and expanding public transit has prompted transit agencies and local governments to set up on-demand systems that include a multimodal, integrated, and connected transportation system [78][79]. For example, the U.S. Federal Transit Administration (FTA, Washington, DC, USA) Sandbox Program funded a range of pilot application-based on-demand projects to provide first/last mile connections to fixed route services [80]. In Canada, the Regional Municipality of Waterloo has launched similar pilot projects in Kitchener, Cambridge, and Waterloo to integrate transit fixed routes with ridesourcing services [81].

Some have speculated that the growth of ridesourcing services is an opportunity to reduce car ownership and automobile dependence [82][13]. Some evidence suggests that the entry of ridesourcing services is attributed to a decline in personal car dependence. For instance, after Uber and Lyft left Austin, Texas, Hampshire et al. [83] found that 45% of the TNCs′ users turned to personal cars and 8.9% of this group purchased an additional personal vehicle in response to the suspension. However, it seems that a part of the inclination to personal cars following the disruption may be justified by changes in travel behavior caused by Uber and Lyft operations in the past. The study is also based on the assumption that previous users of Uber and Lyft have switched to a mode of transport, while people may have switched to a mixed use of transport modes.

Some surveys measured the decline in car ownership due to the availability of ridesourcing services. Of the participants in the study of Henao and Marshall [14] in the Denver region, 13% reported that they own fewer vehicles due to the availability of ridesourcing services. They found that restaurants/bars, working trips to the CBD, airport, hotels, and event venues are the most popular locations that people prefer to substitute driving with ridesourcing. Lavieri et al. [14] indicate that 9% of respondents in their study in Austin, Texas, tend to dispose of one or more household cars due to the availability of ridesourcing services.

Ridesourcing services can open a window of opportunity for planners to minimize parking supply, create new land uses, and reduce overall vehicle miles traveled (VMT) [11][23][82]. For many people, parking is the main reason to substitute ridesourcing for personal driving [25]. TNCs can provide a mobility service to and from areas with low parking supply [84] because ridesourcing drivers never have to search for parking. Therefore, they can reduce overall VMT by eliminating wasteful driving, such as the search for parking at the end of trips [85][36]. Henao and Marshall [85] indicate that about 26% of TNC riders would have driven if these services did not exist and needed a parking spot in Denver.

The growth of ridesourcing services can also be a step forward in reducing congestion and energy use in cities [58][13][86]. Erhardt et al. [11], listed several mechanisms where ridesourcing services may reduce congestion. First, if TNCs shared trips based on a ridesplitting behavior, they would replace the trips that could otherwise be in a vehicle with fewer passengers. Second, travelers may use ridesourcing services to address first and last mile connections to regional transportation. As a result, TNCs may allow passengers to replace driving trips with transit. Finally, TNCs can discourage car ownership by offering an appealing alternative to driving. They can lead people to own fewer cars and shift to public transportation or active modes of transport.

Wenzel et al. [85] believe that ridesourcing services can decrease energy use in several ways. First, in the short term, sharing rides with strangers or polling is an opportunity to reduce VMT. It can significantly reduce miles of travel and the energy consumed in several vehicles with fewer occupants. Second, TNC drivers may ignore the initial increase in a more efficient car′s purchase price since the lower fuel costs may offset the cost in the medium run. Finally, in the long term, riders may retire their existing cars to avoid fixed costs for their mobility need and, as a result, may eliminate the trips they made with their vehicle beforehand. Jin et al. [6] further point out that if TNCs exclusively take advantage of electricity powered driverless cars, the prevalence of ridesourcing services could reduce energy use and urban pollution.

Overall, the confirmed positive impact of ridesourcing services is that they are more efficient than traditional taxis. In the reviewed literature, we identified several environmental opportunities, including increasing public transportation efficiency, reducing car ownership, minimizing parking supply, reducing congestion, and energy consumption. However, there is no evidence that these opportunities are yet exploited.

3.2. Negative Environmental Impacts

While the environmental merit of ridesharing is well documented [69][87], the environmental influence of ridesourcing is uncertain [88]. Theoretically, TNCs may reduce the overall VMT, congestion, energy consumption, and air pollution by increasing taxis and public transit efficiency. However, there is empirical evidence to reject this idea and characterize these services as detrimental to a city′s sustainable environment, as ridesourcing may add more idle cars to the road and attract some public transit users [3][2].

Some research, including Xu et al. [89], poses some doubts about the positive influence of ridesourcing on the public transportation system. It is argued that some passengers make ridesourcing trips which were previously carried out by transit. Some of the trips are also new trips that they might not have otherwise made without the availability of ridesourcing [90]. Based on evidence reported in **Table 1**, between 14 and 58% of ridesourcing trips are substituted with public transport trips. Clewlow and Mishra [25] have found that the introduction of TNCs is correlated with a 15% reduction in transit ridership in major U.S. cities. However, they argue that this effect is not the same for all forms of public transport, as public buses and light rail are more impacted, while heavy rail is benefiting from the new generation of taxi services. While it was initially expected that ridesourcing services would be an alternative to conventional taxis, Rayle et al. [3] have found that most ridesourcing trips in San Francisco are substituting for modes other than a taxi and are, therefore, outside the traditional taxi industry. Similarly, in Brazil, de Souza Silva et al. [51] suggest that 30% of riders would travel by public transport if these services were not available as an alternative.

Table 1. The results of studies on the impact of ridesourcing services on VMT/VKT, empty miles rate, transit substitution, walking or bicycling substitution, driving/carpool/taxi substitution.

.	Author(s)	City/Region	Period	Method	Impact	Target Population	Sample Size	Data Size	Direction [1]
VMT/VKT	[91]	Denver, Colorado	2016	Survey	+83.5%	Lyft/Uber drivers	416 rides	-	Negative
	[11]	San Francisco	2010–2016	Modeling-regression	+7%	San Francisco Bay Area residents	-	-	Negative
	[92]	Paris Region	2017	Survey	No effect	TNC users	1966	-	Non
Empty miles rate	[75]	5 US cities	2014–2015	Modeling	+36% to 45%	UberX drivers	-	-	Negative
	[85]	Austin Texas	June 2016 to April 2017	Modeling	+45%	RideAustin drivers	-	1.5 million rides	Negative
Car sale	[83]	Austin Texas	2016	Survey	+8.9%	Uber and/or Lyft users	1840	-	Positive
	[92]	Paris Region	2017	Survey	No effect	TNC users	1966	-	Non
New trip generation	[25]	7 major US cities	2014–2016	Survey	+22%	Urban residents	4094	-	Negative
	[3]	San Francisco	2014	Survey	+8%	TNC users	380	-	Negative
	[91]	Denver, Colorado	2016	Survey	+12%	Lyft/Uber drivers	416 rides	-	Negative
	[93]	California	2015	Survey	+8%	Residents of California	2400	1975	Negative
	[38]	Santiago, Chile	2017	Modeling	+3%	Uber users	1600	-	Negative
	[94]	Santiago, Chile	2017	survey	5.4%	Santiago residents	1500	-	Negative

.	Author(s)	City/Region	Period	Method	Impact	Target Population	Sample Size	Data Size	Direction [1]
Transit substitution	[25]	7 major US cities	2014–2016	Survey	15%	Urban residents	4094	-	Negative
	[3]	San Francisco	2014	Survey	33%	TNC users	380	-	Negative
	[91]	Denver, Colorado	2016	Survey	22.2%	Lyft/Uber drivers	416 rides	-	Negative
	[95]	7 US cities	2016	Survey	14%	Mobility users	4500	-	Negative
	[48]	New York	2009–2016	Regression model	58.54%	Taxi trips	1458	143,926	Negative
	[93]	California	2015	Survey	22%	Residents of California	2400	1975	Negative
	[51]	Brazilian cities	2017	Logistic regression model	30%	Brazilian Uber users	500	384	Negative
	[6]	New York	2014	Spatial cross-correlation	Mixed effects	Uber pickup records	-	74394 pickup records	Non
	[38]	Santiago, Chile	2017	Modeling	34%	Uber users	1600	-	Negative
	[94]	Santiago, Chile	2017	survey	37.6%	Santiago residents	1500	-	Negative
	[81]	Waterloo, Ontario, Canada	2018–2019	Descriptive analysis	74%	TNC rides	585	-	Negative
	[96]	Bogotá, Colombia	2019	Discrete Choice Models	33%	Uber trips	-	50,760 queries	Negative
	[97]	Chengdu, China	2016	Modeling	33%	DiDi trip data	-	181,172 trips	Negative
Transit extending or complementing	[37]	US cities	2017	Descriptive analysis	27%	National Household Travel Survey (NHTS)	-	-	Positive

.	Author(s)	City/Region	Period	Method	Impact	Target Population	Sample Size	Data Size	Direction [1]
Walking or bicycling substitution	[25]	7 major US cities	2014–2016	Survey	24%	Urban residents	4094	-	Negative
	[3]	San Francisco	2014	Survey	21.0%	TNC users	380	-	Negative
	[95]	7 US cities	2016	Survey	18%	Mobility users	4500	-	Negative
	[93]	California	2015	Survey	20%				Negative
	[91]	Denver, Colorado	2016	Survey	12%	Lyft/Uber drivers	416 rides	-	Negative
	[38]	Santiago, Chile	2017	Modeling	4%	Uber users	1600	-	Negative
	[81]	Waterloo, Ontario, Canada	2018–2019	Descriptive analysis	26%	TNC rides	585	-	Negative
	[35]	Tehran, Iran	2017	Chi-square test	19.7%	Urban residents	2377	-	Negative
	[35]	Cairo, Egypt	2017	Chi-square test	19.3%	Urban residents	2011	-	Negative
	[94]	Santiago, Chile	2017	survey	1.6%	Santiago residents	1500	-	Negative
Driving/taxisubstitution	[25]	7 major US cities	2014–2016	[91] Survey	46%	Urban residents	[98] 4094	-	Positive
	[3]	San Francisco	2014	Survey	46%	TNC users	380	-	Positive
	[91]	Denver, Colorado	2016	Survey	52.1%	Lyft/Uber drivers	416 rides	-	Positive
[39]	[95]	7 US cities	2016	Survey	42%	Mobility users	4500	-	Positive
	[83]	Austin Texas [99]	2016	Survey	45%	Uber and/or Lyft users	1840	-	Positive
[85]	[38]	Santiago, Chile	2017	Modeling	52%	Uber users	1600	-	Positive

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Regarding the first reason, Cramer and Krueger [75] calculate that the empty miles rate of Uber drivers in Seattle is about 45% and that it is about 36% for Los Angeles. However, Wenzel et al. [85] note that Cramer and Krueger failed to include the empty commuting miles at the beginning and end of shifts. Wenzel et al. [85] estimate that this commuting distance is about 19% of the total VMT for RideAustin drivers. Besides, they estimate that TNC drivers travel 21% longer distances to pick up passengers in Austin, Texas, and drive 55% more miles between the end of a trip and the next ride. There are three reasons why some TNC drivers opt to circulate rather than parking immediately after a ride: (1) TNC drivers often cannot quickly and accurately locate the waiting positions of riders. Therefore, cruising on the road helps them to find a new request in a shorter time [100]; (2) Drivers mainly search for

.	Author(s)	City/Region	Period	Method	Impact	Target Population	Sample Size	Data Size	Direction [1]
[52]									
	[96]	Bogotá, Colombia	2019	Discrete Choice Models	30% [89]	Uber trips	-	50,760 queries	Positive
	[94]	Santiago, Chile	2017	survey	68%	Santiago residents	1500	-	Positive

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Source: Authors. [1] By direction, we mean the overall impact of finding on urban sustainability.

However, there are cases in which ridesourcing services both complement and compete with the public transit system [97]. For example, Jin et al. [6] show that ridesourcing services have contrasting impacts on public transport in New York, but their negative influence is more prevalent. They note that ridesourcing services compete with public transport in Manhattan, where public transport coverage is high. At the same time, it complements public transport at night and in areas with insufficient public transport services.

References

1. Hughes, R.; MacKenzie, D. Transportation network company wait times in Greater Seattle, and relationship to socioeconomic indicators. J. Transp. Geogr. 2016, 56, 36–44.
2. Wenzel, T.; Rames, C.; Kontou, E.; Henao, A. Travel and energy implications of ridesourcing service in Austin, Texas. Transp. Res. Part D Transp. Environ. 2019, 70, 18–34.
3. Rayle, L.; Dai, D.; Chan, N.; Cervero, R.; Shaheen, S. Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco. Transp. Policy 2016, 45, 168–178.
4. Tarabay, R.; Abou-Zeid, M. Modeling the choice to switch from traditional modes to ridesourcing services for social/recreational trips in Lebanon. Transportation 2019, 47, 1733–1763.
5. Brown, A. Redefining Car Access. J. Am. Plan. Assoc. 2019, 85, 83–95.
6. Jin, S.T.; Kong, H.; Sui, D.Z. Uber, Public Transit, and Urban Transportation Equity: A Case Study in New York City. Prof. Geogr. 2019, 71, 315–330.
7. Shokoohyar, S.; Sobhani, A.; Sobhani, A. Impacts of trip characteristics and weather condition on ride-sourcing network: Evidence from Uber and Lyft. Res. Transp. Econ. 2020, 80, 100820.
8. Su, Q.; Wang, D.Z. Morning commute problem with supply management considering parking and ride-sourcing. Transp. Res. Part C Emerg. Technol. 2019, 105, 626–647.
9. Deohans, A.; Kumari, A.; Saha, J.; JayaKalyani, K.; Sharma, S. Management Analysis of Uber; San Francisco, 2019. Available online: https://www.sfcta.org/sites/default/files/2019-05/TNCs_Congestion_Report_181015_Finals.pdf (accessed on 18 July 2020).
10. Lavieri, P.S.; Dias, F.F.; Juri, N.R.; Kuhr, J.; Bhat, C.R. A Model of Ridesourcing Demand Generation and Distribution. Transp. Res. Rec. 2018, 2672, 31–40.
11. Anderson, D.N. Wheels in the Head: Ridesharing as Monitored Performance. Surveill. Soc. 2016, 14, 240–258.
12. Wang, H.; Yang, H. Ridesourcing systems: A framework and review. Transp. Res. Part B Methodol. 2019, 129, 122–155.
13. Young, M. Ride-hailing’s impact on Canadian cities: Now let’s consider the long game. Can. Geogr. 2019, 63, 171–175.

14. Sun, D.; Ding, X. Spatiotemporal evolution of ridesourcing markets under the new restriction policy: A case study in Shanghai. Transp. Res. Part A Policy Pr. 2019, 130, 227–239.
15. Brodeur, A.; Nield, K. An empirical analysis of taxi, Lyft and Uber rides: Evidence from weather shocks in NYC. J. Econ. Behav. Organ. 2018, 152, 1–16.
16. Sabouri, S.; Brewer, S.; Ewing, R. Exploring the relationship between ride-sourcing services and vehicle ownership, using both inferential and machine learning approaches. Landsc. Urban Plan. 2020, 198, 103797.
17. Henao, A.; Marshall, W. The impact of ride-hailing on vehicle miles traveled. Transportation 2018, 46, 2173–2194.
18. Mitra, S.; Bae, Y.; Ritchie, S. Use of Ride-Hailing Services among Older Adults in the United States. Transp. Res. Rec. 2019, 2673, 700–710.
19. Kirk, D.S.; Cavalli, N.; Brazil, N. The implications of ridehailing for risky driving and road accident injuries and fatalities. Soc. Sci. Med. 2020, 250, 112793.
20. Glöss, M.; McGregor, M.; Brown, B. Designing for Labour. In Proceedings of the Conference on Human Factors in Computing Systems-Proceedings, San Jose, CA, USA, 7–12 May 2016.
21. Greenwood, B.; Temple University; Wattal, S. Show Me the Way to Go Home: An Empirical Investigation of Ride-Sharing and Alcohol Related Motor Vehicle Fatalities. MIS Q. 2017, 41, 163–187.
22. Drunk-driving, M.A. Uber Reveals Ridesharing Services Important Innovation to Reduce Drunk-Driving; 2015; Available online: https://www.prnewswire.com/news-releases/new-report-from-madd-uber-reveals-ridesharing-services-important-innovation-to-reduce-drunk-driving-300026334.html (accessed on 11 March 2020).
23. Xue, M.; Yu, B.; Du, Y.; Wang, B.; Tang, B.; Wei, Y.-M. Possible Emission Reductions From Ride-Sourcing Travel in a Global Megacity: The Case of Beijing. J. Environ. Dev. 2018, 27, 156–185.
24. Clewlow, R.; Mishra, G. Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States (Issue October); University of California: Berkeley, CA, USA, 2017.
25. Dills, A.K.; Mulholland, S.E. Ride-Sharing, Fatal Crashes, and Crime. South. Econ. J. 2018, 84, 965–991.
26. Kontou, E.; McDonald, N. Associating ridesourcing with road safety outcomes: Insights from Austin, Texas. PLoS ONE 2021, 16, e0248311.
27. Conway, M.W.; Salon, D.; King, D.A. Trends in Taxi Use and the Advent of Ridehailing, 1995–2017: Evidence from the US National Household Travel Survey. Urban Sci. 2018, 2, 79.

28. Brodeur, A.; Nield, K. Has Uber Made It Easier to Get a Ride in the Rain? IZA Discussion Paper; IZA: Bonn, Germany, 2016.
29. Beojone, C.V.; Geroliminis, N. On the inefficiency of ride-sourcing services towards urban congestion. Transp. Res. Part C Emerg. Technol. 2021, 124, 102890.
30. Alemi, F.; Circella, G.; Mokhtarian, P.; Handy, S. What drives the use of ridehailing in California? Ordered probit models of the usage frequency of Uber and Lyft. Transp. Res. Part C Emerg. Technol. 2019, 102, 233–248.
31. Yu, H.; Peng, Z.-R. Exploring the spatial variation of ridesourcing demand and its relationship to built environment and socioeconomic factors with the geographically weighted Poisson regression. J. Transp. Geogr. 2019, 75, 147–163.
32. Spurlock, C.A.; Sears, J.; Wong-Parodi, G.; Walker, V.; Jin, L.; Taylor, M.; Duvall, A.; Gopal, A.; Todd, A. Describing the users: Understanding adoption of and interest in shared, electrified, and automated transportation in the San Francisco Bay Area. Transp. Res. Part D Transp. Environ. 2019, 71, 283–301.
33. Goodspeed, R.; Xie, T.; Dillahunt, T.R.; Lustig, J. An alternative to slow transit, drunk driving, and walking in bad weather: An exploratory study of ridesourcing mode choice and demand. J. Transp. Geogr. 2019, 79.
34. Mostofi, H.; Masoumi, H.; Dienel, H.-L. The Association between Regular Use of Ridesourcing and Walking Mode Choice in Cairo and Tehran. Sustainability 2020, 12, 5623.
35. Grahn, R.; Harper, C.; Hendrickson, C.; Qian, Z.; Matthews, H.S. Socioeconomic and usage characteristics of transportation network company (TNC) riders. Transportation 2019, 47, 3047–3067.
36. King, D.A.; Conway, M.W.; Salon, D. Do For-Hire Vehicles Provide First Mile/Last Mile Access to Transit? Transp. Find. 2020, 14, 1–7.
37. Tirachini, A.; Gomez-Lobo, A. Does ride-hailing increase or decrease vehicle kilometers traveled (VKT)? A simulation approach for Santiago de Chile. Int. J. Sustain. Transp. 2019, 14, 187–204.
38. Young, M.; Farber, S. The who, why, and when of Uber and other ride-hailing trips: An examination of a large sample household travel survey. Transp. Res. Part A Policy Pr. 2019, 119, 383–392.
39. Deka, D.; Fei, D. A comparison of the personal and neighborhood characteristics associated with ridesourcing, transit use, and driving with NHTS data. J. Transp. Geogr. 2019, 76, 24–33.
40. Borowski, E. Disparities in ridesourcing demand for mobility resilience: A multilevel analysis of neighborhood effects in Chicago, Illinois. arXiv 2020, arXiv:2010.15889.

41. Jiang, W.; Zhang, L. The Impact of the Transportation Network Companies on the Taxi Industry: Evidence from Beijing's GPS Taxi Trajectory Data. IEEE Access 2018, 6, 12438–12450.
42. Jin, S.T.; Kong, H.; Wu, R.; Sui, D.Z. Ridesourcing, the sharing economy, and the future of cities. Cities 2018, 76, 96–104.
43. Edelman, B.G.; Geradin, D. Efficiencies and regulatory shortcuts: How should we regulate companies like Airbnb and Uber. Stanf. Technol. Law Rev. 2015, 19, 293.
44. Rekhviashvili, L.; Sgibnev, W. Uber, Marshrutkas and socially (dis-)embedded mobilities. J. Transp. Hist. 2018, 39, 72–91.
45. Brown, A.; LaValle, W. Hailing a change: Comparing taxi and ridehail service quality in Los Angeles. Transportation 2020, 48, 1007–1031.
46. Ge, Y.; Knittel, C.R.; MacKenzie, D.; Zoepf, S. Racial and Gender Discrimination in Transportation Network Companies. Natl. Bur. Econ. Res. 2016.
47. Jiang, J. More Americans Are Using Ride-Hailing Apps; Pew Research Center: Washington, DC, USA, 2019.
48. Wang, F.; Ross, C.L. New potential for multimodal connection: Exploring the relationship between taxi and transit in New York City (NYC). Transportation 2017, 46, 1051–1072.
49. Yu, H.; Peng, Z.-R. The impacts of built environment on ridesourcing demand: A neighbourhood level analysis in Austin, Texas. Urban Stud. 2019, 57, 152–175.
50. Liu, X.; Xu, W.W. Adoption of ride-sharing apps by Chinese taxi drivers and its implication for the equality and wellbeing in the sharing economy. Chin. J. Commun. 2018, 12, 7–24.
51. Silva, L.A.D.S.; de Andrade, M.O.; Maia, M.L.A. How does the ride-hailing systems demand affect individual transport regulation? Res. Transp. Econ. 2018, 69, 600–606.
52. Sui, Y.; Zhang, H.; Song, X.; Shao, F.; Yu, X.; Shibasaki, R.; Sun, R.; Yuan, M.; Wang, C.; Li, S.; et al. GPS data in urban online ride-hailing: A comparative analysis on fuel consumption and emissions. J. Clean. Prod. 2019, 227, 495–505.
53. Zha, L.; Yin, Y.; Du, Y. Surge pricing and labor supply in the ride-sourcing market. Transp. Res. Part B Methodol. 2018, 117, 708–722.
54. Nie, Y. How can the taxi industry survive the tide of ridesourcing? Evidence from Shenzhen, China. Transp. Res. Part C Emerg. Technol. 2017, 79, 242–256.
55. Wang, S.; Smart, M. The disruptive effect of ridesourcing services on for-hire vehicle drivers' income and employment. Transp. Policy 2020, 89, 13–23.
56. Barbour, N.; Zhang, Y.; Mannering, F. An exploratory analysis of the role of socio-demographic and health-related factors in ridesourcing behavior. J. Transp. Health 2020, 16, 100832.

57. Brazil, N.; Kirk, D. Uber and Metropolitan Traffic Fatalities in the United States. Am. J. Epidemiol. 2016, 184, 192–198.
58. Wang, F.; Zhu, H.; Liu, X.; Lu, R.; Li, F.; Li, H.; Zhang, S. Efficient and Privacy-Preserving Dynamic Spatial Query Scheme for Ride-Hailing Services. IEEE Trans. Veh. Technol. 2018, 67, 11084–11097.
59. Schwieterman, J.; Smith, C.S. Sharing the ride: A paired-trip analysis of UberPool and Chicago Transit Authority services in Chicago, Illinois. Res. Transp. Econ. 2018, 71, 9–16.
60. Malos, S.; Lester, G.V.; Virick, M. Uber Drivers and Employment Status in the Gig Economy: Should Corporate Social Responsibility Tip the Scales? Empl. Responsib. Rights J. 2018, 30, 239–251.
61. Mulley, C.; Kronsell, A. Workshop 7 report: The “uberisation” of public transport and mobility as a service (MaaS): Implications for future mainstream public transport. Res. Transp. Econ. 2018, 69, 568–572.
62. Tirachini, A. Ride-hailing, travel behaviour and sustainable mobility: An international review. Transportation 2019, 47, 2011–2047.
63. Moghadasi, A.N. Opportunities and Threats: The Necessity of Research in Dealing with the Rapid Spread of Coronavirus disease 2019 (COVID-19) in Iran. Arch. Clin. Infect. Dis. 2020, 15.
64. Phun, V.K.; Kato, H.; Chalermpong, S. Paratransit as a connective mode for mass transit systems in Asian developing cities: Case of Bangkok in the era of ride-hailing services. Transp. Policy 2019, 75, 27–35.
65. EDR. Uber’s Economic Impacts across the United States. 2018. Available online: https://drive.google.com/file/d/1P6HMbPc8T91Y8NlYyFGv8NQS9g4ckAq9/view (accessed on 11 September 2020).
66. Ashkrof, P.; Correia, G.H.D.A.; Cats, O.; Van Arem, B. Understanding ride-sourcing drivers’ behaviour and preferences: Insights from focus groups analysis. Res. Transp. Bus. Manag. 2020, 37, 100516.
67. Guo, Y.; Xin, F.; Barnes, S.J.; Li, X. Opportunities or threats: The rise of Online Collaborative Consumption (OCC) and its impact on new car sales. Electron. Commer. Res. Appl. 2018, 29, 133–141.
68. Remy, C.; Brakewood, C.; Ghahramani, N.; Kwak, E.J.; Peters, J. Transit Information Utilization during an Extreme Weather Event: An Analysis of Smartphone App Data. Transp. Res. Rec. 2018, 2672, 90–100.
69. Amey, A.; Attanucci, J.; Mishalani, R.G. Real-Time Ridesharing: Opportunities and challenges in using mobile phone technology to improve rideshare services. Transp. Res. Rec. 2011, 2217,

103–110.

70. Notar, B.E.; Min, K.S.; Gautam, R. Echoes of Colonial Logic in Re-Ordering “Public” Streets: From colonial rangoon to postcolonial Yangon. Transfers 2018, 8, 55–73.
71. Brail, S. Promoting innovation locally: Municipal regulation as barrier or boost? Geogr. Compass 2017, 11, e12349.
72. Ward, J.W.; Michalek, J.J.; Azevedo, I.L.; Samaras, C.; Ferreira, P. On-demand ridesourcing has reduced per-capita vehicle registrations and gasoline use in US States. In Proceedings of the Transportation Research Board 97th Annual Meeting, Washington, DC, USA, 7–11 January 2018.
73. Henao, A.; Marshall, W. An analysis of the individual economics of ride-hailing drivers. Transp. Res. Part A Policy Pract. 2019, 130, 440–451.
74. Brown, A.E. Prevalence and Mechanisms of Discrimination: Evidence from the Ride-Hail and Taxi Industries. J. Plan. Educ. Res. 2019.
75. Cramer, J.; Krueger, A.B. Disruptive Change in the Taxi Business: The Case of Uber. Am. Econ. Rev. 2016, 106, 177–182.
76. Shaheen, S.; Cohen, A. Shared ride services in North America: Definitions, impacts, and the future of pooling. Transp. Rev. 2018, 39, 427–442.
77. Zgheib, N.; Abou-Zeid, M.; Kaysi, I. Modeling demand for ridesourcing as feeder for high capacity mass transit systems with an application to the planned Beirut BRT. Transp. Res. Part A Policy Pr. 2020, 138, 70–91.
78. Shaheen, S.; Cohen, A.P.; Broader, J.; Davis, R.; Brown, L.; Neelakantan, R.; Gopalakrishna, D. Mobility on Demand Planning and Implementation: Current Practices, Innovations, and Emerging Mobility Futures (ICF & B. T. S. R. C. University of California (Eds.)). 2020. Available online: https://rosap.ntl.bts.gov/view/dot/50553 (accessed on 11 March 2020).
79. Yan, X.; Levine, J.; Zhao, X. Integrating ridesourcing services with public transit: An evaluation of traveler responses combining revealed and stated preference data. Transp. Res. Part C Emerg. Technol. 2019, 105, 683–696.
80. Weinreich, D.P.; Reeves, S.M.; Sakalker, A.; Hamidi, S. Transit in flex: Examining service fragmentation of app-based, on-demand transit services in Texas. Transp. Res. Interdiscip. Perspect. 2020, 5.
81. Terry, J.; Bachmann, C. Spatial Characteristics of Transit-Integrated Ridesourcing Trips and Their Competitiveness with Transit and Walking Alternatives. Transp. Res. Rec. 2020, 2674, 329–340.
82. Aarhaug, J.; Olsen, S. Implications of ride-sourcing and self-driving vehicles on the need for regulation in unscheduled passenger transport. Res. Transp. Econ. 2018, 69, 573–582.

83. Hampshire, R.C.; Simek, C.; Fabusuyi, T.; Chen, X. Measuring the Impact of an Unanticipated Suspension of Ride-Sourcing in Austin, Texas. SSRN Electron. J. 2017.

84. Ghaffar, A.; Mitra, S.; Hyland, M. Modeling determinants of ridesourcing usage: A census tract-level analysis of Chicago. Transp. Res. Part C Emerg. Technol. 2020, 119, 102769.

85. Henao, A.; Marshall, W.E. The impact of ride hailing on parking (and vice versa). J. Transp. Land Use 2019, 12.

86. Luo, Y.; Jia, X.; Fu, S.; Xu, M. pRide: Privacy-Preserving Ride Matching Over Road Networks for Online Ride-Hailing Service. IEEE Trans. Inf. Forensics Secur. 2018, 14, 1791–1802.

87. Sarriera, J.M.; Álvarez, G.E.; Blynn, K.; Alesbury, A.; Scully, T.; Zhao, J. To share or not to share: Investigating the social aspects of dynamic ridesharing. Transp. Res. Rec. 2017, 2605, 109–117.

88. Lee, J.; Tyner, W.; Vasavda, N. Moving Minds: The Next Generation of Real-Time Transit Information in San Francisco. Transp. Res. Rec. 2018, 2672, 523–535.

89. Xu, Z.; Yin, Y.; Zha, L. Optimal parking provision for ride-sourcing services. Transp. Res. Part B Methodol. 2017, 105, 559–578.

90. Shaheen, S.; Cohen, A.; Randolph, M.; Farrar, E.; Davis, R.; Nichols, A. Shared Mobility Policy Playbook; Institute of Transportation Studies: Berkeley, CA, USA, 2019.

91. Hall, J.D.; Palsson, C.; Price, J. Is Uber a substitute or complement for public transit? J. Urban Econ. 2018, 108, 36–50.

92. Bekka, A.; Louvet, N.; Adoue, F. Impact of a ridesourcing service on car ownership and resulting effects on vehicle kilometers travelled in the Paris Region. Case Stud. Transp. Policy 2020, 8.

93. Alemi, F.; Circella, G.; Handy, S.; Mokhtarian, P. What influences travelers to use Uber? Exploring the factors affecting the adoption of on-demand ride services in California. Travel Behav. Soc. 2018, 13, 88–104.

94. Tirachini, A.; del Río, M. Ride-hailing in Santiago de Chile: Users' characterisation and effects on travel behaviour. Transp. Policy 2019, 82, 46–57.

95. Murphy, S.F.C. Shared Mobility and the Transformation of Public Transit. In Shared Mobility and the Transformation of Public Transit; The National Academies Press: Washington, DC, USA, 2016.

96. Oviedo, D.; Granada, I.; Perez-Jaramillo, D. Ridesourcing and Travel Demand: Potential Effects of Transportation Network Companies in Bogotá. Sustainability 2020, 12, 1732.

97. Kong, H.; Zhang, X.; Zhao, J. How does ridesourcing substitute for public transit? A geospatial perspective in Chengdu, China. J. Transp. Geogr. 2020, 86, 102769.

98. Schaller, B. The New Automobility: Lyft, Uber and the Future of American Cities; Schaller Consulting: Brooklyn, NY, USA, 2018.
99. Gehrke, S.R.; Felix, A.; Reardon, T.G. Substitution of Ride-Hailing Services for More Sustainable Travel Options in the Greater Boston Region. Transp. Res. Rec. 2019, 2673, 438–446.
100. Zhu, W.; Lu, J.; Yang, Y. A Pick-Up Points Recommendation System for Ridesourcing Service. Sustainability 2019, 11, 1097.